

CBCT Imaging and Dental Sleep Medicine

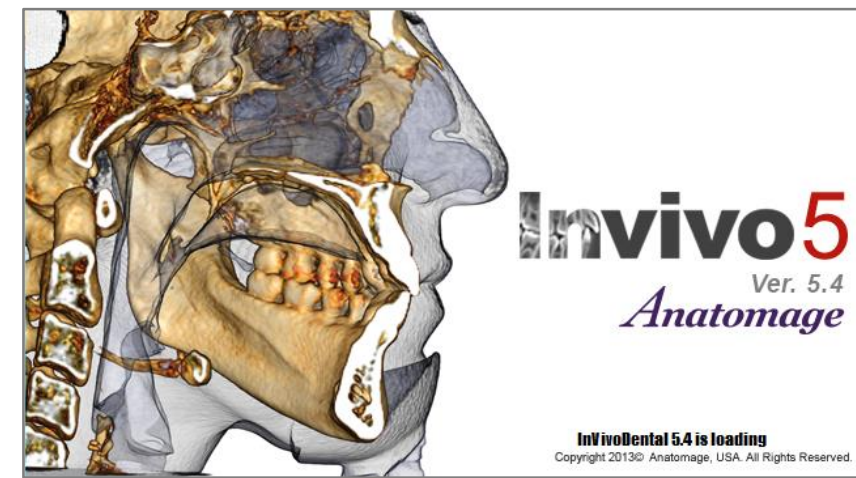
Presented by
Douglas L. Chenin, DDS

Learning Objectives

1. Discuss the foundations of Sleep Medicine Principles and Diagnostics
2. Explore the role of CBCT imaging within Dental Sleep Medicine
3. Explore craniofacial anatomy consistent with Obstructive Sleep Apnea

My History with CBCT Imaging

- Anatomage Inc
 - Director of Clinical Affairs
 - 2006 – 2011
- Invivo5 / TxSTUDIO
 - 3D Implant Planning Software
 - Orthodontic Analysis and 3D Models
 - TMJ Analysis
 - Airway Analysis
- Anatomage Guide
 - Implant Surgical Guide System



My History with CBCT Imaging

- BeamReaders Inc
 - Director of Implant Services
 - 2011 – 2015
- Implemented Implant Planning and Surgical Guide Services
 - CBCT-Based Implant Consults
 - Surgical Guide Planning



My History with CBCT Imaging

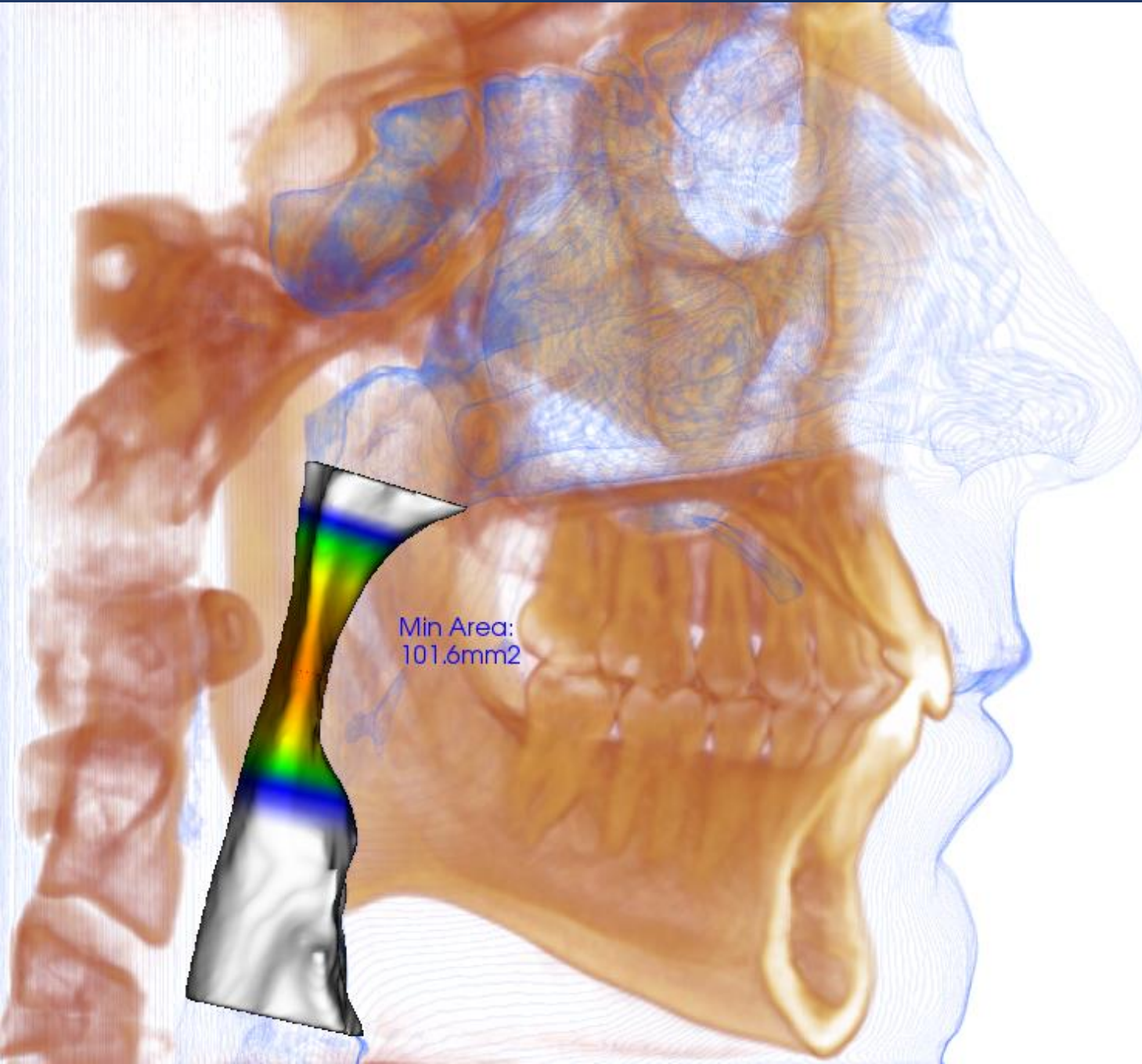
- Clinically Correct Inc
 - Founder and CEO
 - 2012 – Present
- CBCT focused continuing education
 - DVD Productions
 - Anatomage Software Training
 - Implant Surgical Guide Series
 - Presentations, Workshops, Webinars, etc.



My History with CBCT Imaging

- San Francisco Dental Sleep Medicine
 - Director and General Dentist
 - 2016 – Present
- Dental Sleep Medicine Focused Practice
 - Oral Appliance Therapy
 - CBCT 3D Imaging
 - Pathology Screening
 - Airway, TMJ, Sinus Assessments
 - Orthodontic Analysis





Part One: Foundations of Sleep Medicine Principles and Diagnostics

1. OSA is Rooted in Craniofacial Anatomy

- Retrognathic mandible or maxilla
- Micrognathic mandible or maxilla
- Large tongue (scalloping is a sign)
- Inadequate arch form (cross-bite)
- Long / thick soft palate and uvula
- Thick Neck
- Obesity
 - OSA has a strong correlation with obesity but many patients with OSA are not obese
 - Many of my patients are fit and young



2. Many “routine dental” patients have OSA

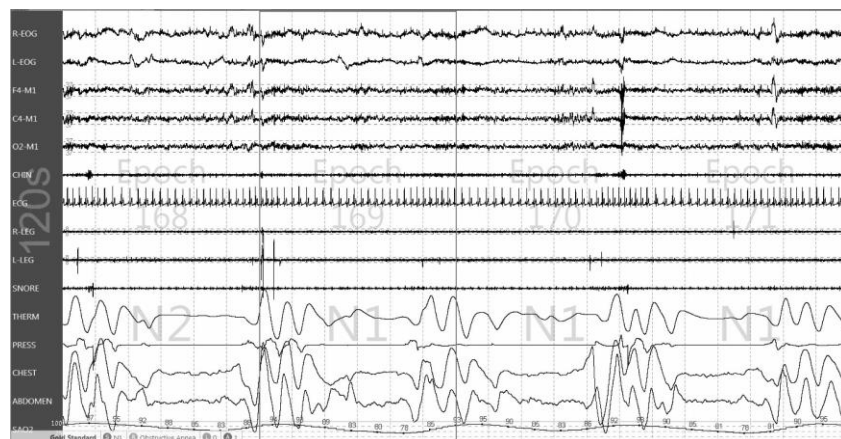
- Most people with OSA still do not know that they have a potentially life threatening disorder
- Up to 80% of people remain undiagnosed despite adequate access to health care

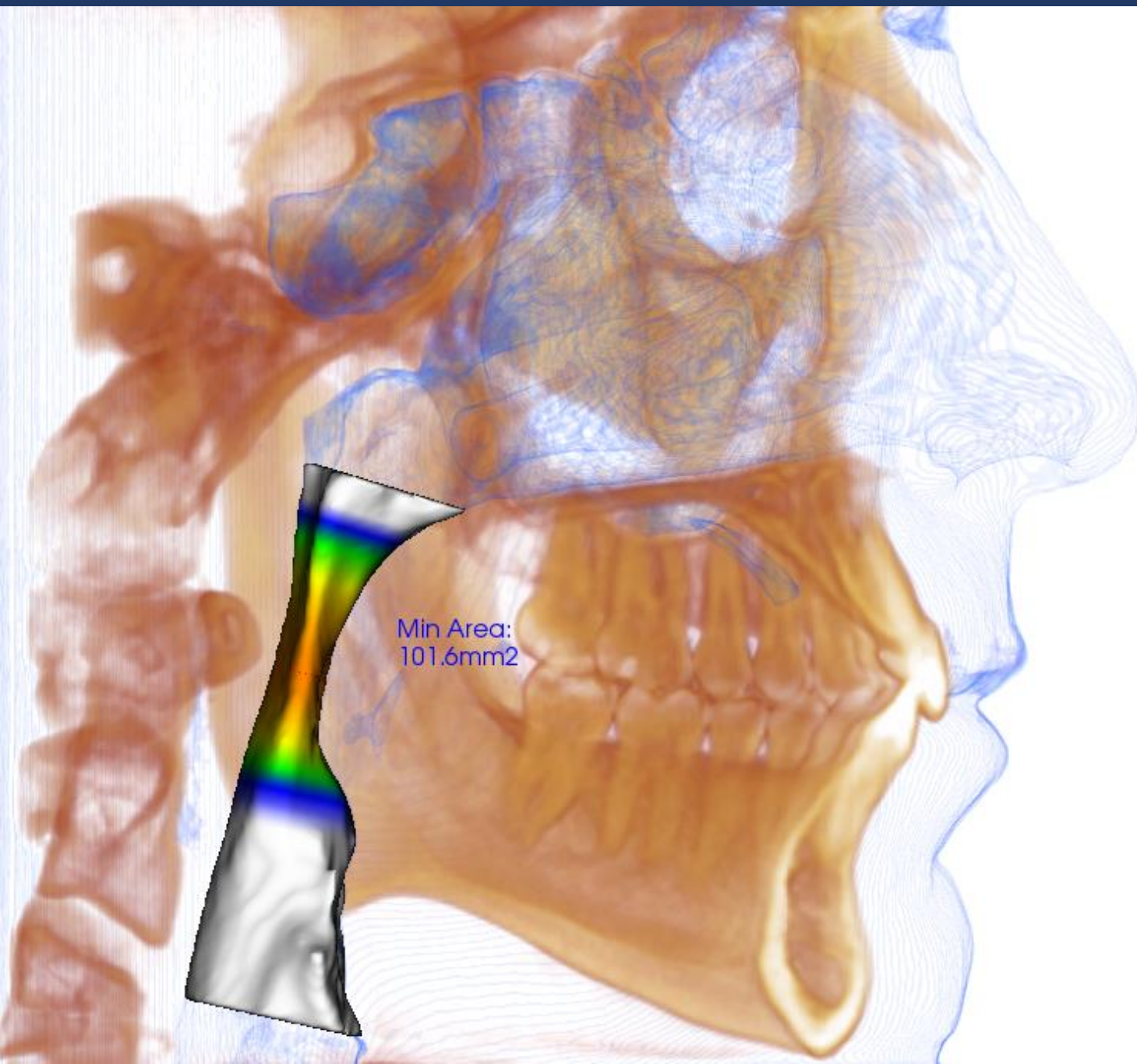


Lee W, Nagubadi S, Kryger MH, Mokhlesi B. Epidemiology of Obstructive Sleep Apnea: a Population-based Perspective. *Expert review of respiratory medicine*. 2008;2(3):349-364. doi:10.1586/17476348.2.3.349.

CBCT and Diagnostics

- CBCT imaging (and other imaging modalities) are not diagnostic for any of the various Sleep Related Breathing Sleep Disorders
- Sleep Related Breathing Disorders are diagnosed with polysomnography by Sleep Physician
- Polysomnography uses multiple channels to record physiological functions while a patient sleeps over a period of time
 - Respiratory muscle effort, oxygen saturation, airflow, heart rate, body position, parapharyngeal noise, brain waves, etc



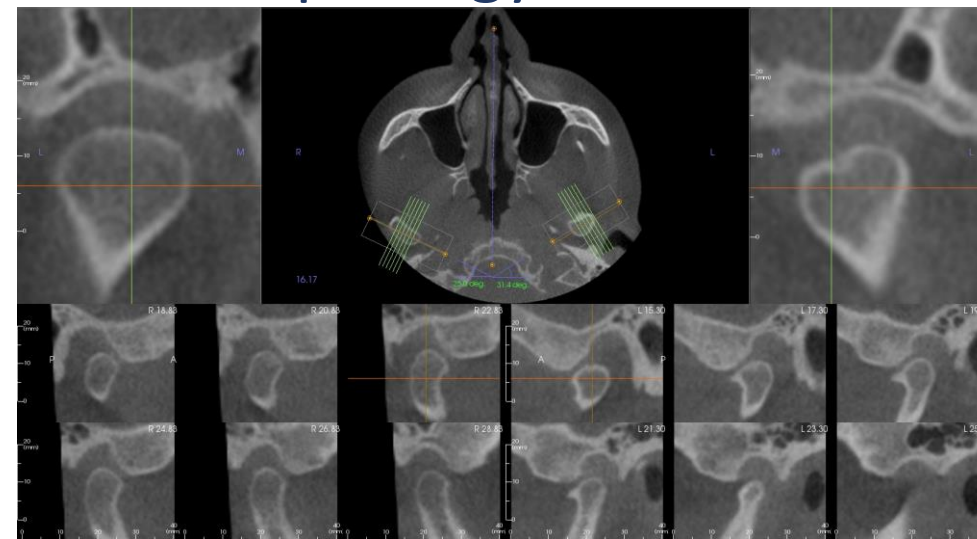
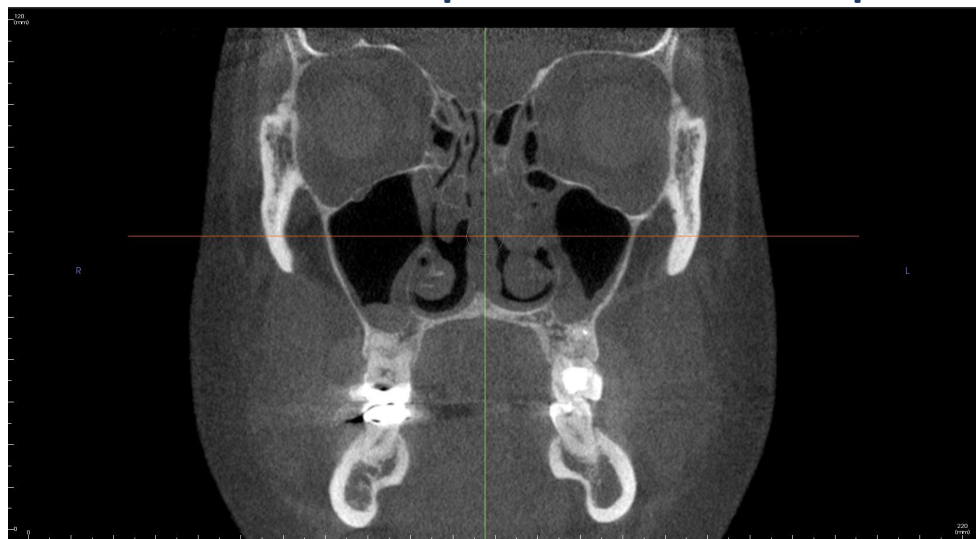


Part Two:
The Role of CBCT in Dental
Sleep Medicine

Part Three:
An Exploration of the
Craniofacial Anatomy
Consistent with Obstructive
Sleep Apnea

The Value of CBCT in Dental Sleep Medicine

- Patients with OSA often have related or coexisting issues with their nasal passageways, sinuses, temporomandibular joints, cervical vertebrae, dental relationships, function and occlusion
- OSA has a pathophysiology rooted in craniofacial anatomy
- CBCT imaging provides a comprehensive imaging modality that illustrates a patient's complete craniofacial morphology



CBCT and Diagnostics

- CBCT imaging, compared to PSG, gives us a static image of a patient that represents the ***best case scenario*** of what their anatomy looks like, not how it functions
 - Patient is usually in the upright position
 - Patient is awake
 - The image represents one timepoint
- However, it does provide a great insight into how their anatomy may function and where/which anatomical features are involved in this OSA and may complicate their treatment with Oral Appliance Therapy



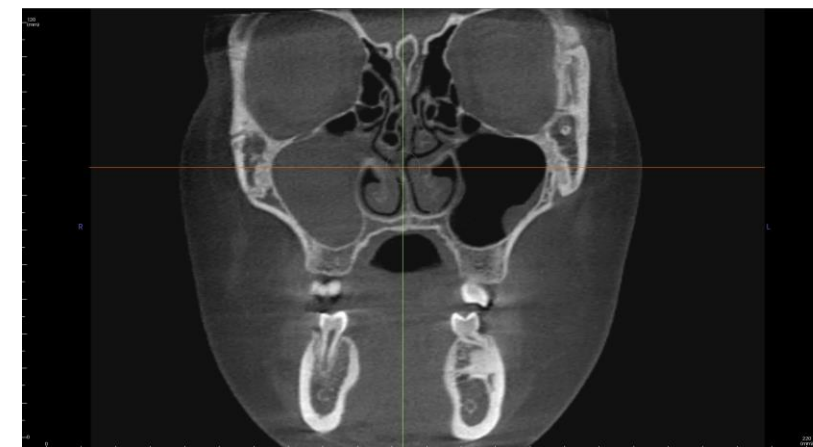
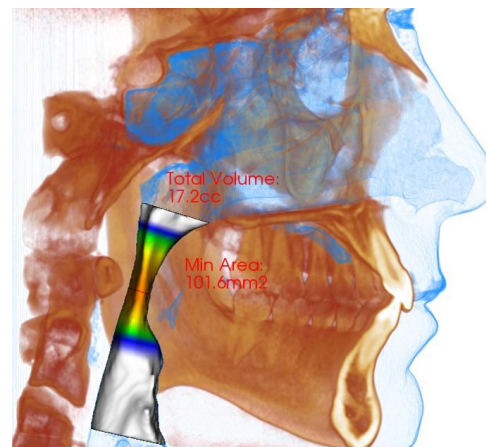
OSA is Rooted in Craniofacial Anatomy (Expanded)

- Retrognathic mandible or maxilla
- Micrognathic mandible or maxilla
- Inadequate arch form (cross-bite)
- Steep palatal vault
- Nasal issues, mouth breathing, etc
- Long / thick soft palate and uvula
- Large tongue (scalloping is a sign)
- Narrow palatoglossal arch
- Narrow palatopharyngeal arch
- Thick neck / Obesity
 - Face and tongue store fat



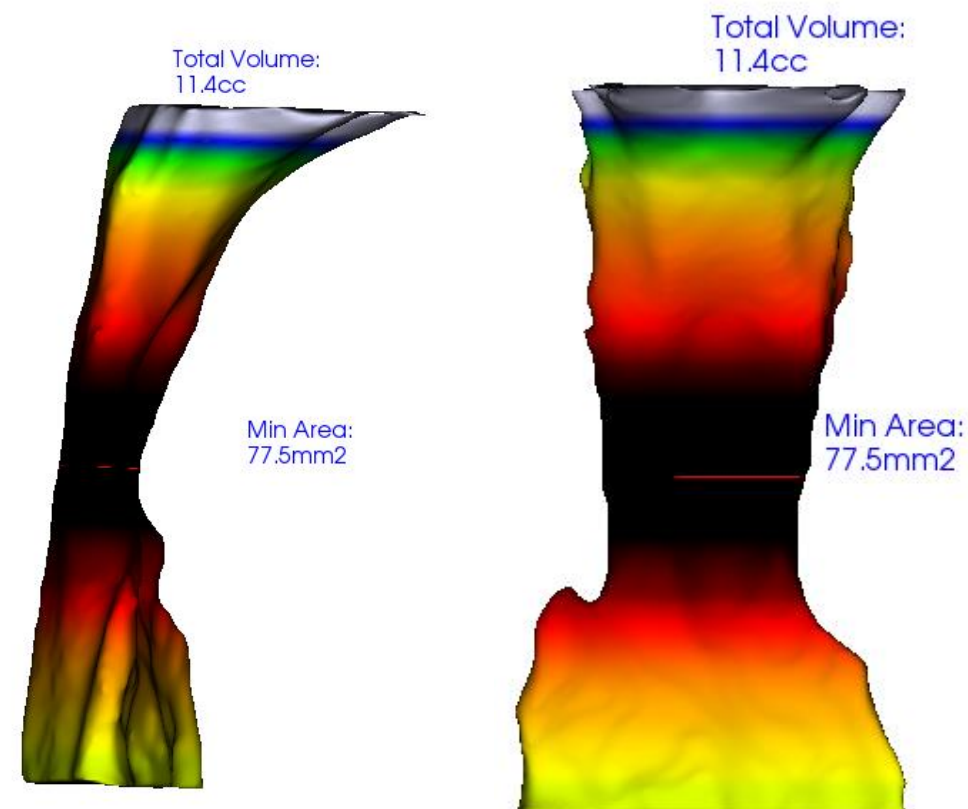
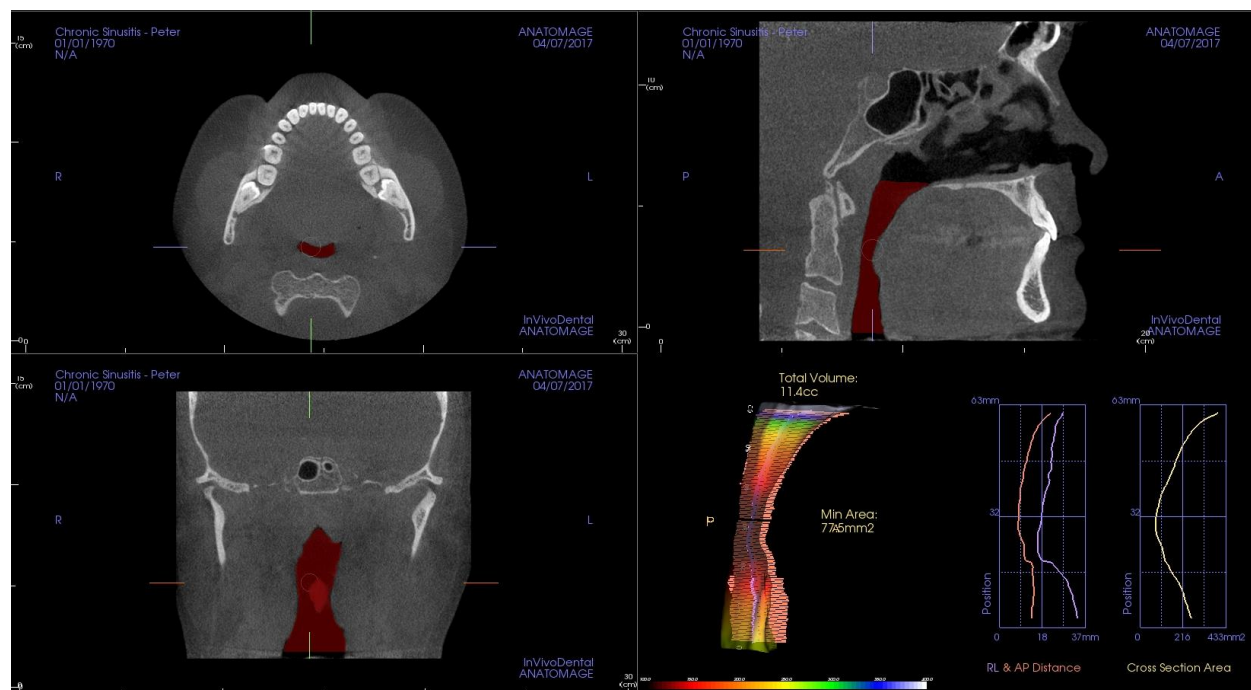
The Assessment and Diagnostic Value of CBCT

1. Assessment of the location and severity of airway obstruction sites
 - Radiographic diagnostics relating airway pathology (swollen adenoids and tonsils)
2. Assessment and diagnostics relating to nasal passageways and sinuses
3. Assessment and diagnostics relating to skeletal and dental classifications
4. Assessment and diagnostics relating to the TMJ and cervical vertebrae
5. Assessment and diagnostics relating to oral maxillofacial pathology



1. Airway obstruction site assessments

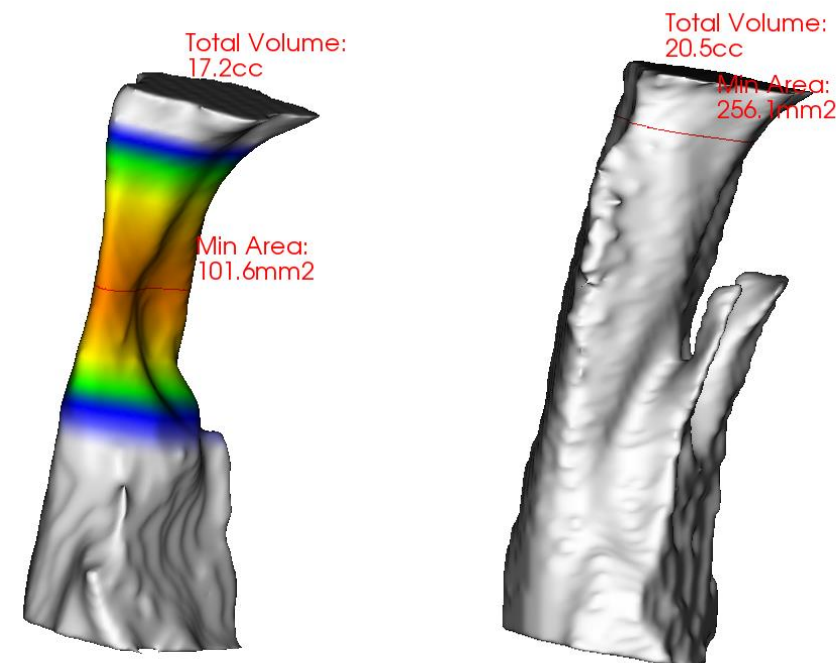
- The Airway Analysis tool
 - Locates and calculates the MCA (Minimum Cross-sectional Area)
 - Calculates the total volume
 - Provides AP and lateral measurements



Rules of Thumb for CBCT Airway Assessments

The MCA Risk Correlation – 50/100/150

- High Risk for OSA = 0-50mm²
- Mod Risk for OSA = 50-100mm²
- Low Risk for OSA = 100-150mm²

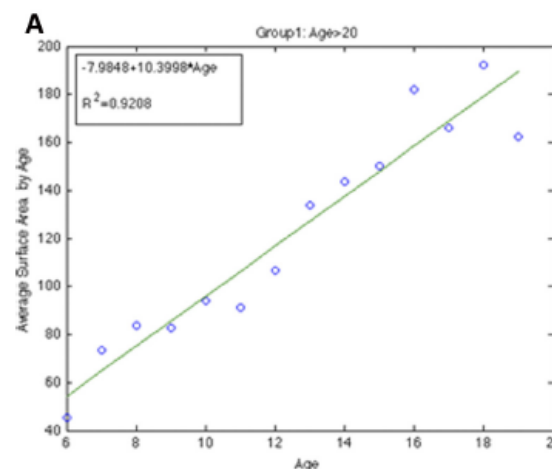
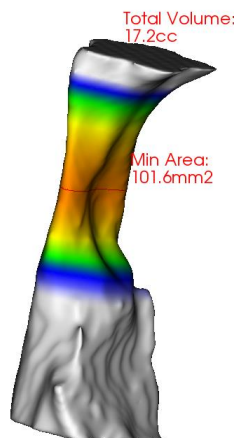


- Lowe AA, Gionhaku N, Takeuchi K, Fleetham JA. Three-dimensional CT reconstructions of tongue and airway in adult subjects with obstructive sleep apnea. Am J Orthod Dentofacial Orthop. 1986 Nov;90(5):364-74.
- Avrahami E, Solomonovich A, Englender M. Axial CT measurements of the cross-sectional area of the oropharynx in adults with obstructive sleep apnea syndrome. AJNR Am J Neuroradiol. 1996 Jun-Jul;17(6):1107-11.
- Ogawa T, Enciso R, Shintaku WH, Clark GT. Evaluation of cross-section airway configuration of obstructive sleep apnea. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007 Jan;103(1):102-8. Epub 2006 Sep 1.

Rules of Thumb for CBCT Airway Assessments

The MCA Age/Norm Correlation

- MCA should be ~10X a patient's age (up to 20yrs)
 - Airway size is increasing as anatomy grows
- MCA stable from 20-40yrs, decreases after 40yrs



Airway Growth and Development: A Computerized 3-Dimensional Analysis

Stephen A. Schendel, MD, DDS, FACS,*
Richard Jacobson, DMD, MS,† and Sadri Khalessi, MS, PhD‡

Purpose: The present study was undertaken to investigate the changes in the normal upper airway during growth and development using 3-dimensional computer analysis from cone-beam computed tomography (CBCT) data to provide a normative reference.

Methods: The airway size and respiratory mode are known to have a relationship to facial morphology and the development of a malocclusion. The use of CBCT, 3-dimensional imaging, and automated computer analysis in treatment planning allows the upper airway to be precisely evaluated. In the present study, we evaluated the growth of the airway using 3-dimensional analysis and CBCT data from age 6 through old age, in 1500 normal individuals.

Results: The airway size and length increase until age 20 at which time a variable period of stability occurs. Next, the airway at first decreases slowly in size and then, after age 40, more rapidly. Normative data are provided in the present study for age groups from 6 to 60 years in relation to the airway total volume, smallest cross-sectional area and vertical length of the airway.

Conclusions: This 3-dimensional data of the upper airway will provide a normative reference as an aid in the early understanding of respiration and dentofacial anatomy, which will help in early treatment planning.

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J Oral Maxillofac Surg 70:2174-2183, 2012

Comprehensive treatment of the facial skeleton and occlusion requires an understanding of all functional variables, including the upper airway.¹ Numerous reports have shown a causal relationship between the upper airway and respiratory mode in the development of facial morphology and malocclusion. In addition, the same factors are important in understanding the surgical management of obstructive sleep apnea.^{2,5} The recent development of cone-beam computed tomography (CBCT), 3-dimensional (3D) imaging, and computer simulation in treatment planning

provide the opportunity to more precisely evaluate individuals than with standard radiographs and with less radiation than a medical CT scan at a lower cost.⁶⁻¹⁰ Despite the extensive published data on respiration, dentofacial deformities, and obstructive sleep apnea, the exact relationship remains unclear. Specifically, the 3D anatomy of the upper airway in relation to the dentofacial form and their importance in normal respiration are unknown. In addition, knowledge of airway development and growth in children and airway changes in adults is needed in orthodontics and orthognathic surgery treatment planning.

The airway extending from the tip of the nose to the epiglottis can be visualized on a conventional CBCT scan.¹¹ Because the scan also includes the jaws, teeth, cranial base, spine, and facial soft tissues, an opportunity exists to evaluate the functional and developmental relationships between these structures.¹ The skeletal support for the airway is provided by the cranial base (superiorly), spine (posteriorly), nasal septum (anterosuperiorly), and jaws and hyoid bone (anteriorly). Airway obstructions or encroachments, when present, can be visualized, and the calculation of the airway dimensions could help identify and localize the anatomic region or regions of the obstruction.

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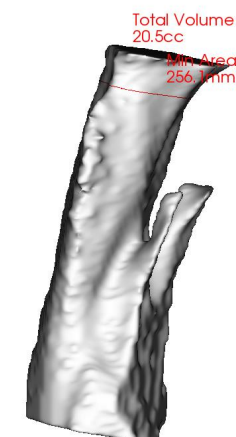
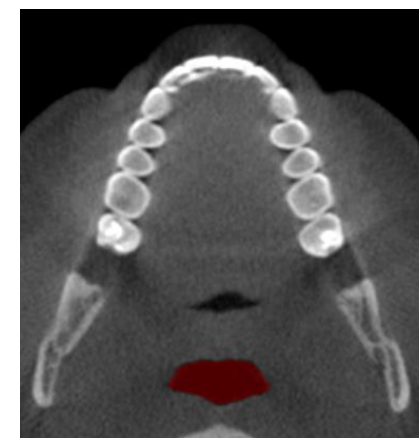
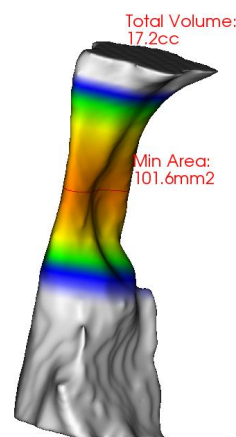
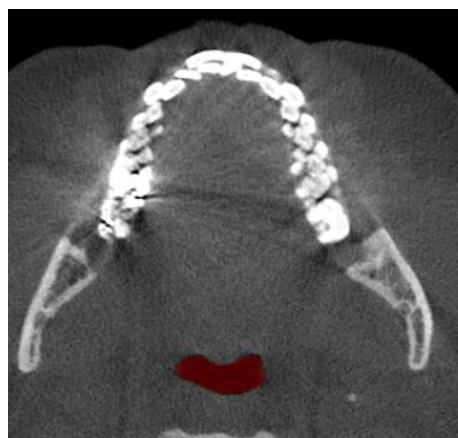
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- Schendel SA, Jacobson R, Khalessi S. Airway growth and development: a computerized 3-dimensional analysis. J Oral Maxillofac Surg. 2012 Sep;70(9):2174-83. doi: 10.1016/j.joms.2011.10.013. Epub 2012 Feb 9.

Rules of Thumb for CBCT Airway Assessments

The Airway Shape Correlation

- OSA patients present with a slightly more elliptical shaped airway and is often indented by the posterior aspect of the tongue or soft palate
 - OSA patients have smaller lateral and AP dimensions at the MCA



- Ogawa T, Enciso R, Shintaku WH, Clark GT. Evaluation of cross-section airway configuration of obstructive sleep apnea. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007 Jan;103(1):102-8. Epub 2006 Sep 1.
- Enciso R, Nguyen M, Shigeta Y, Ogawa T, Clark GT. Comparison of CBCT parameters and sleep questionnaires in sleep apnea patients and controls. . Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109(2):285-293.

CBCT Airway Assessments Appear in Radiology Reports

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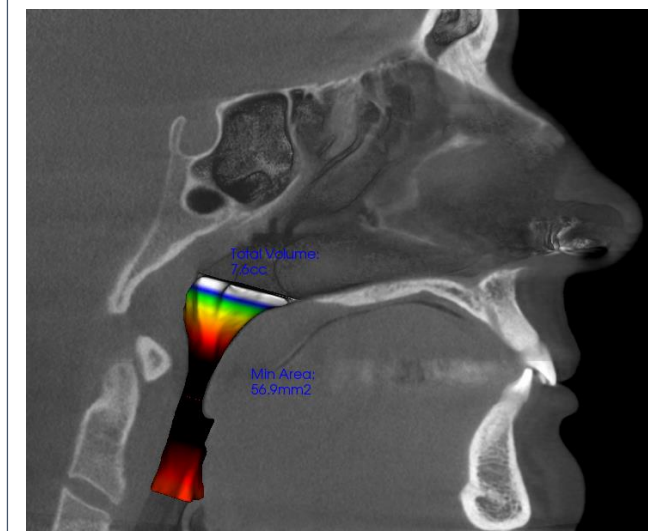
IMPRESSIONS

- Airway analysis: the small airway dimension, having a minimal cross-sectional area of approximately 57mm², indicates a risk factor for sleep disordered breathing, noting that breathing disorders can be multifactorial, which may include the presence of loose or swollen soft tissues, poor muscle tone, airway inflammation, and skeletal development.
- Paranasal sinus mucosal thickenings: given that mucosal thickening is seen in three of the four paranasal sinuses, recommend evaluation by medical ENT to rule out irregularity.

Sincerely,

Kent A. Thompson

Kent Thompson, DDS
Oral & Maxillofacial Radiologist, Orthodontist



1. Airway Assessments

- CBCT is Diagnostic for swollen adenoids (lymphatic tissue aka the pharyngeal tonsil)



Severe Swollen Adenoids



WNL Adenoids

Case provided by Dr. Juan-Carlos Quintero

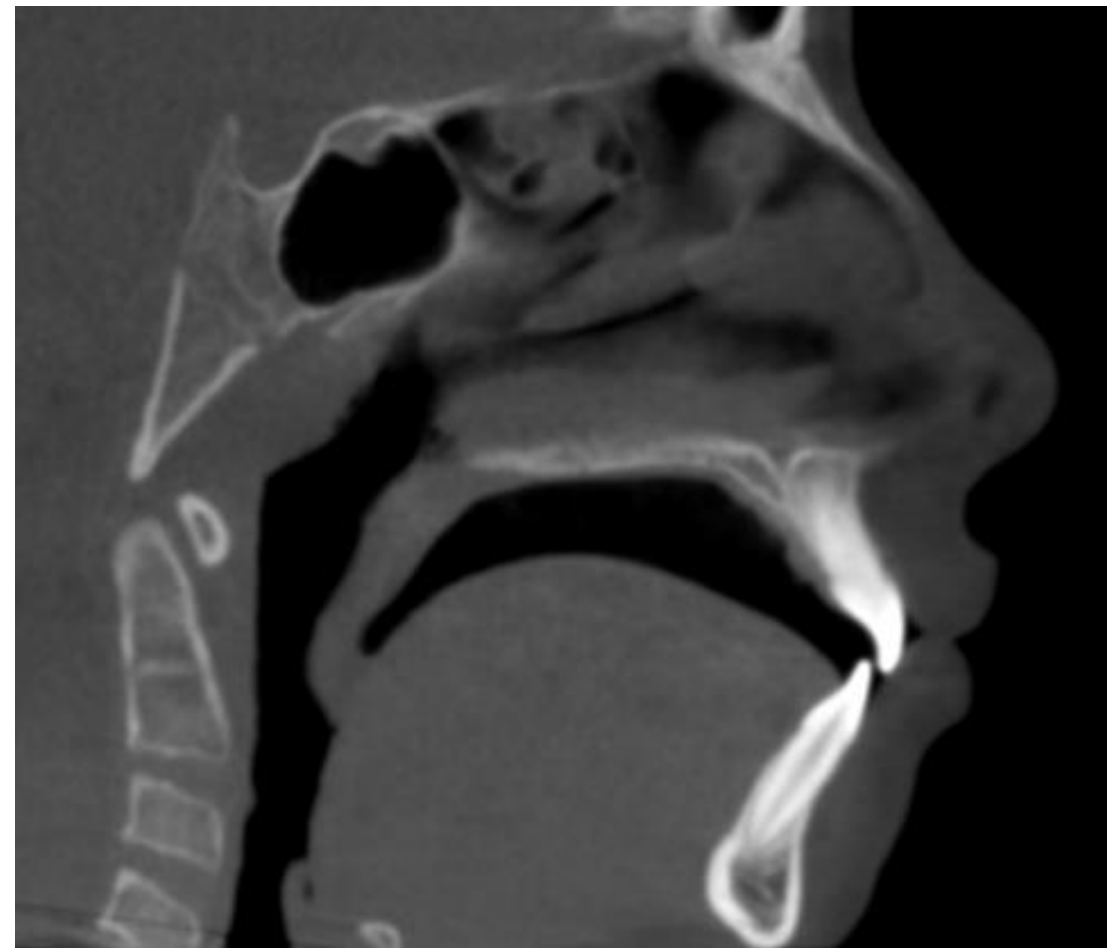
1. Airway Assessments

Sample Case – Pediatric Adenoid Case

- Swollen adenoids
- Low tongue posture
- Thin nasal passageways
- Suspected mouth breathing



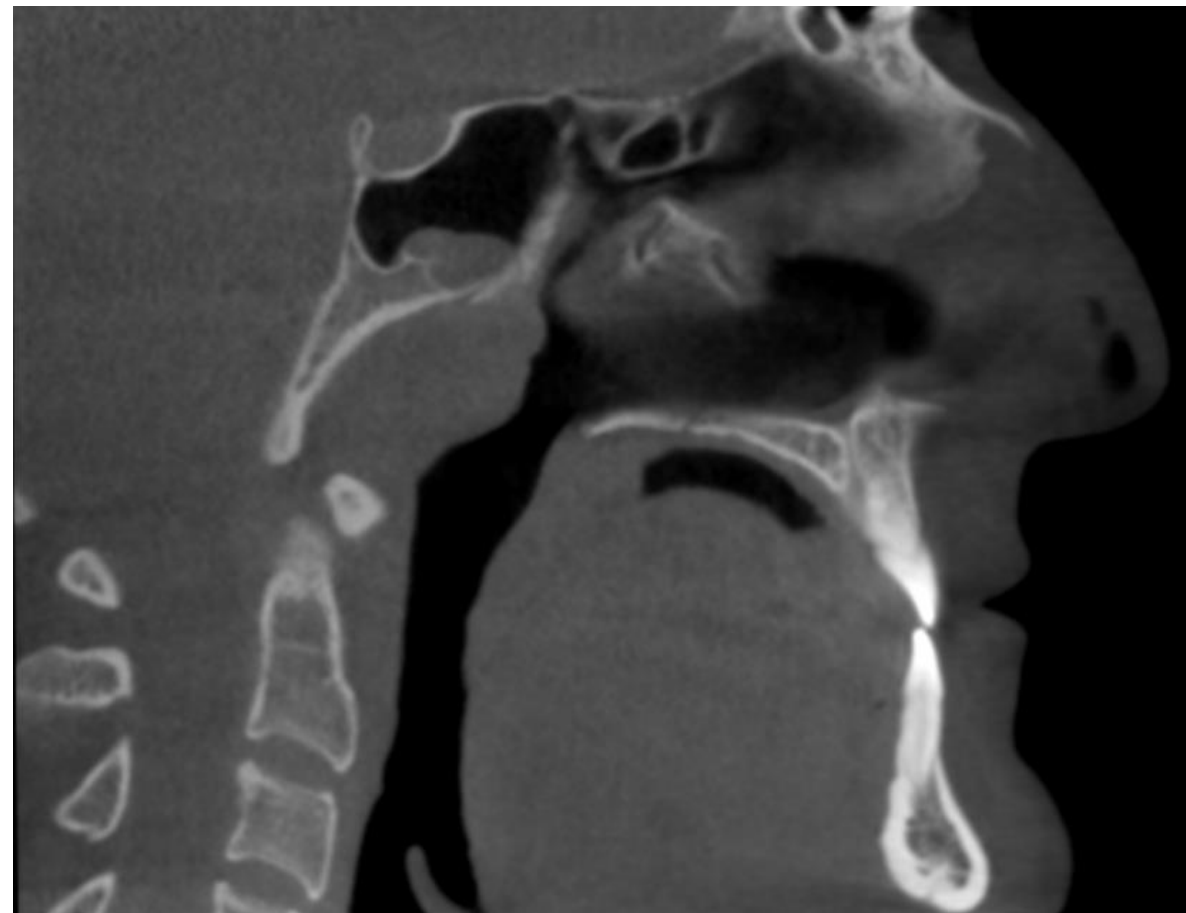
Case provided by Dr. Sean Carlson



1. Airway Assessments

Sample Case – Adult Swollen Adenoids

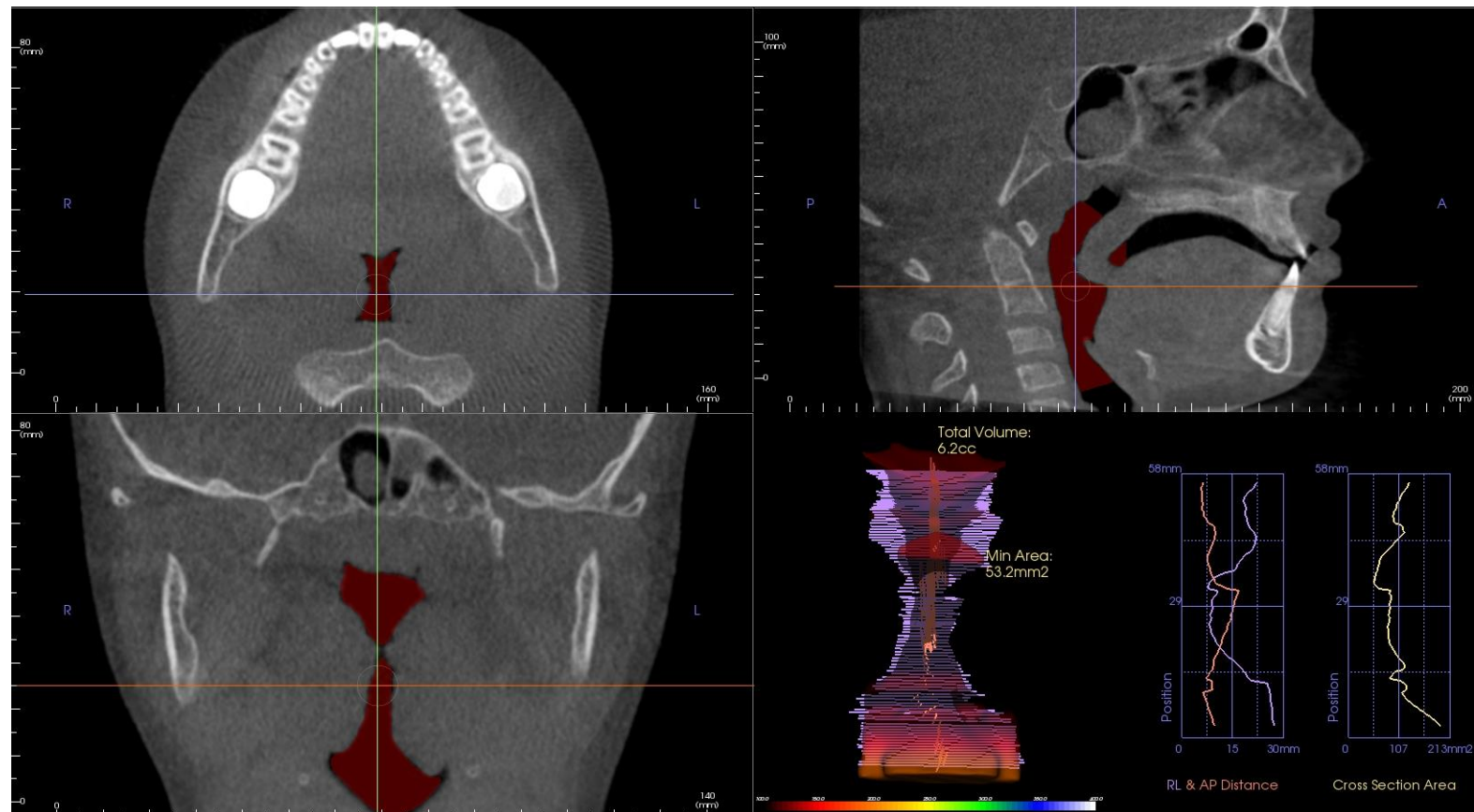
- 24 years old
- Swollen adenoids
- Maxillary retrognathia
- Maxillary micrognathia
- Low tongue posture
- Posterior Cross-bite

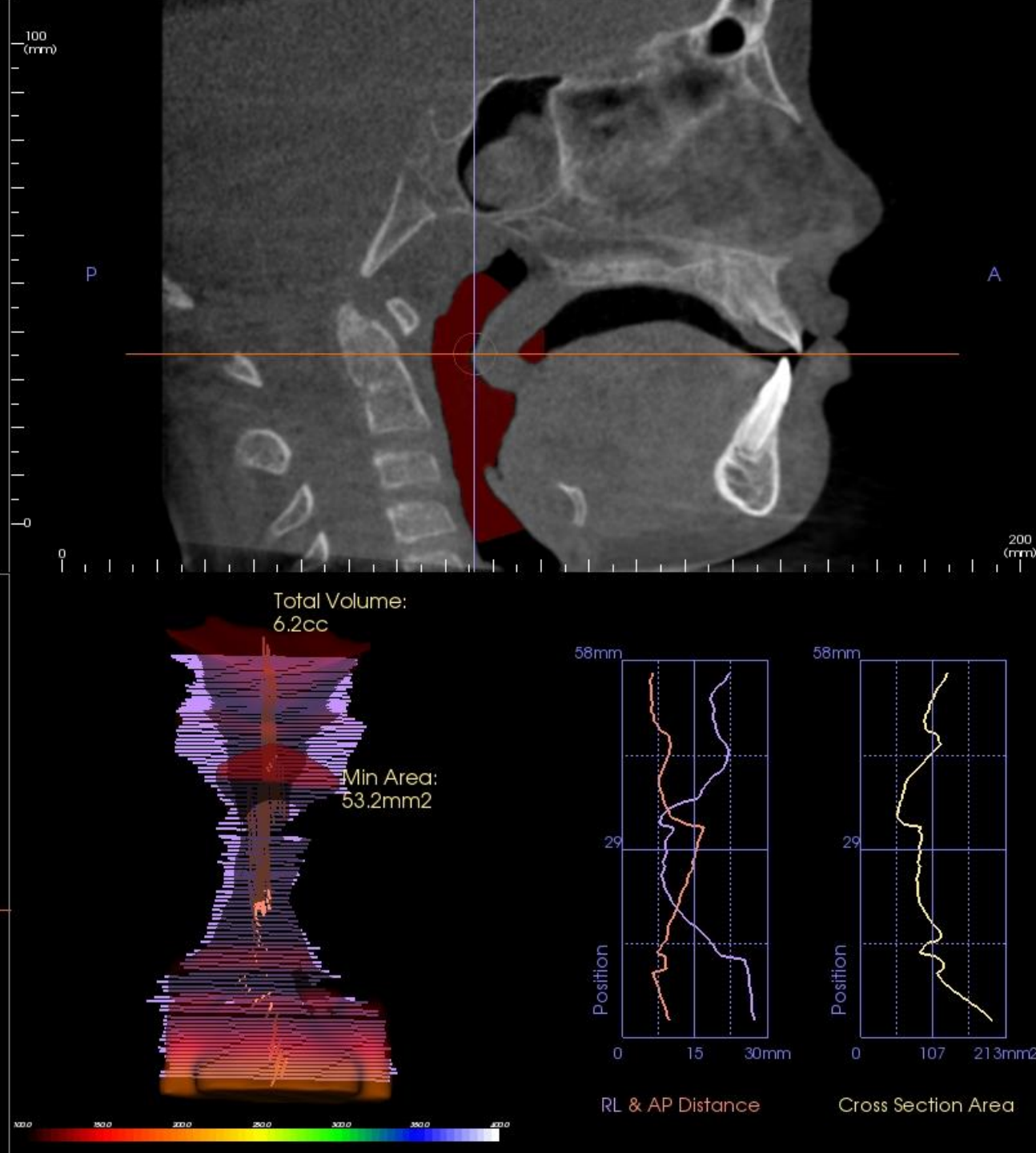
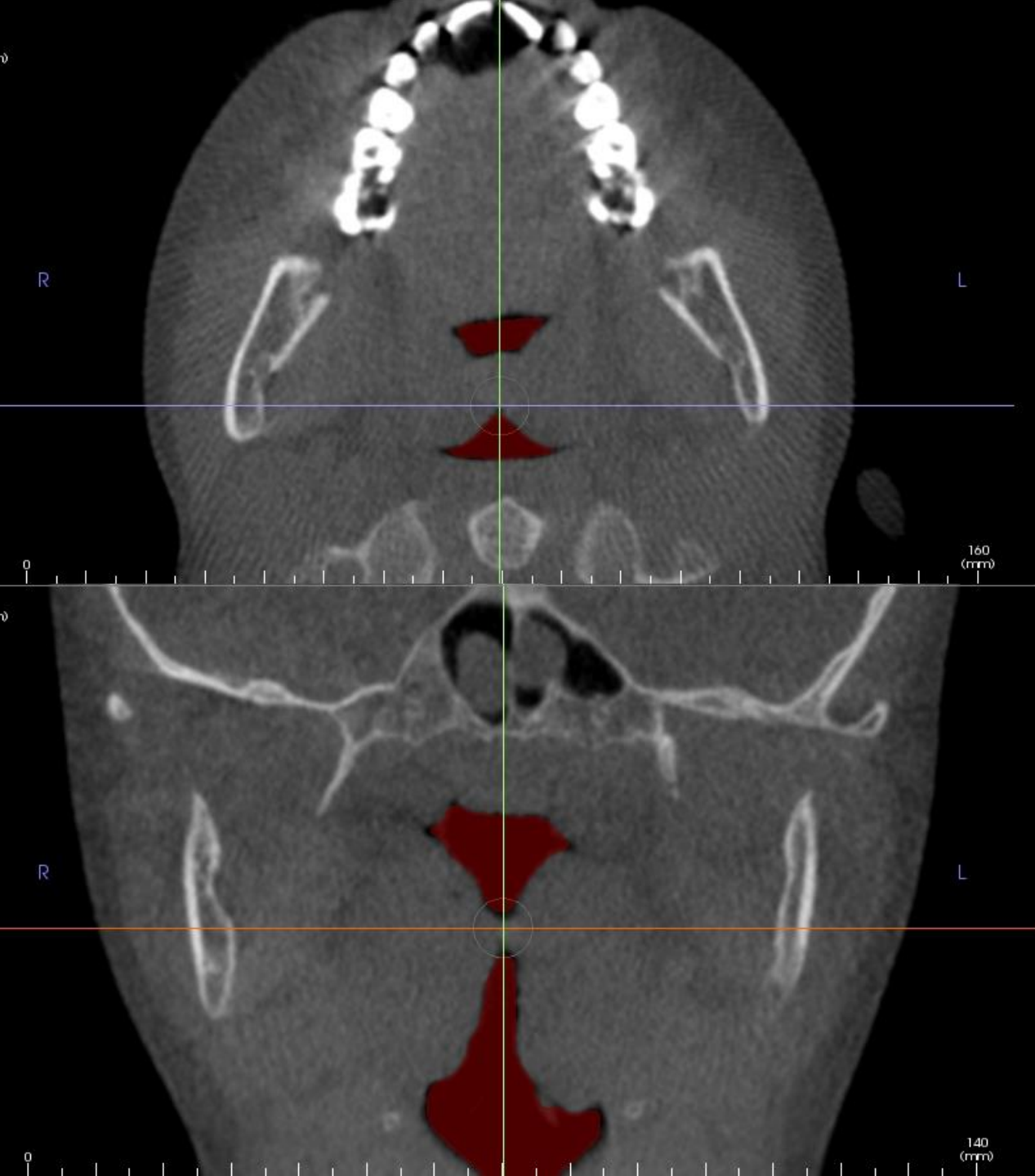


Case provided by Dr. Juan-Carlos Quintero

Pediatric Airway Assessments

Diagnostic for swollen adenoids and palatine tonsils (“Kissing Tonsils”)

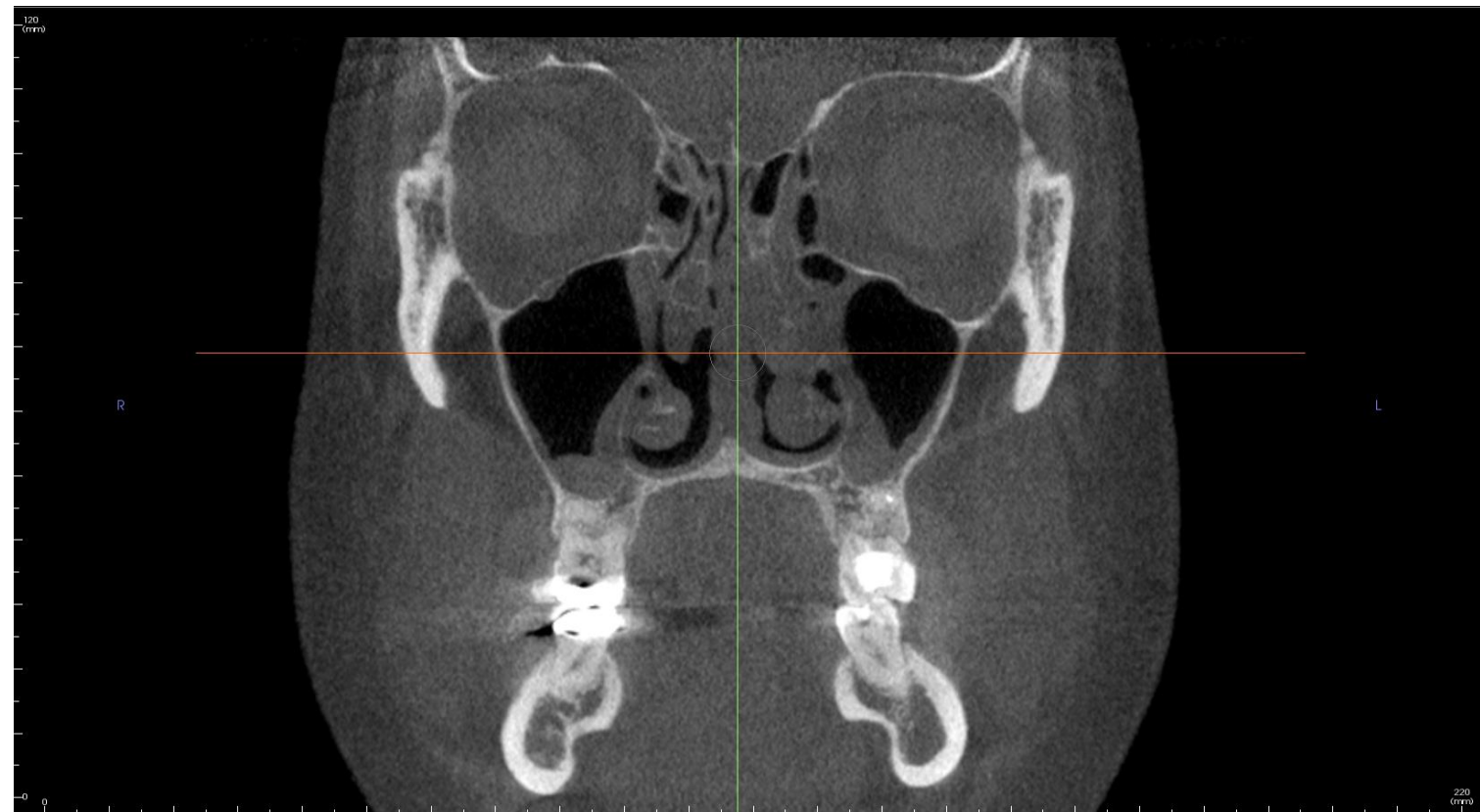




2. Diagnostics for Nasal Passageway and Sinuses

Sample Case

- Pan-sinusitis
- Rhinitis
- Allergist / ENT referral



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- Signs of increase in the mucosal thickening were noted from the floor and walls of the maxillary sinuses, frontal sinus, from selected ethmoidal air cells and from the anterior wall of sphenoid sinus. This is consistent with allergies or another condition of inflammatory origin (pan-sinusitis). The antromeat complexes were NOT completely patent/clear.

2. Diagnostics for Nasal Passageway and Sinuses

Sample Case

- Deviated septum
- Mucosal thickening



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The nasal septum deviates to the left, contacting the left inferior concha, which could present a slight alteration to airflow patterns through the nasal cavity.

Paranasal sinus mucosal thickenings: given that mucosal thickening is seen in three of the four paranasal sinuses, recommend evaluation by medical ENT to rule out irregularity.

2. Diagnostics for Nasal Passageway and Sinuses

Sample Case

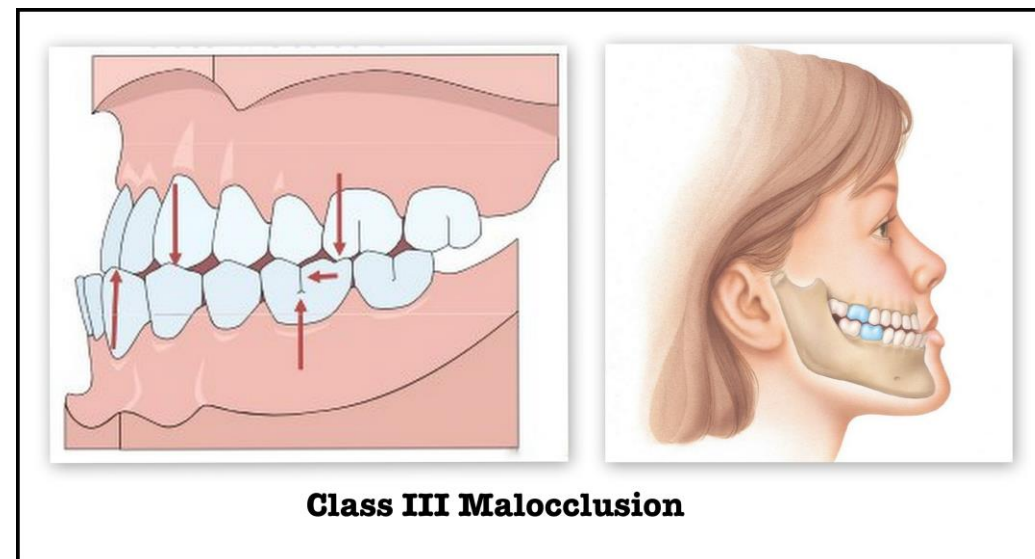
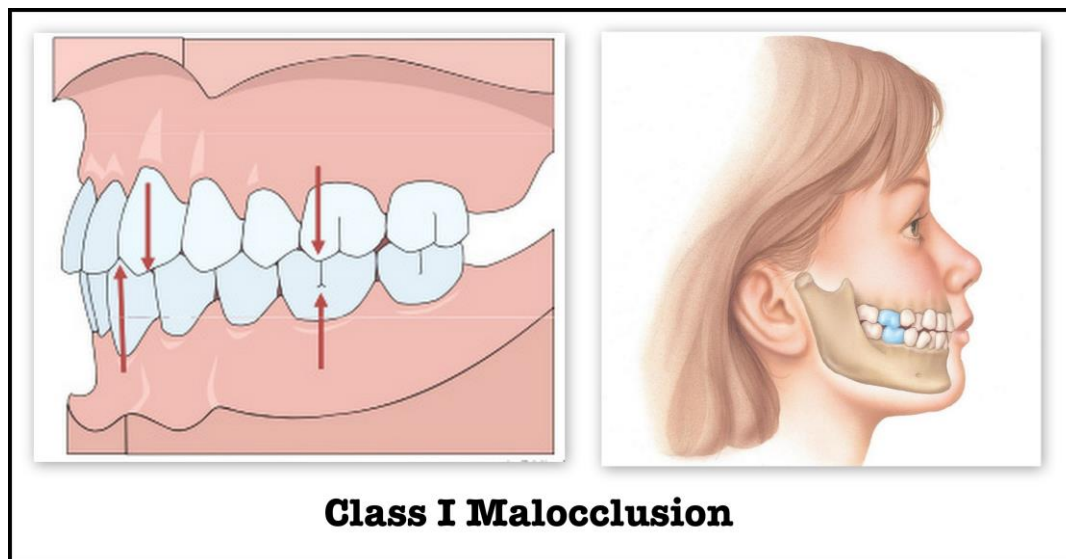
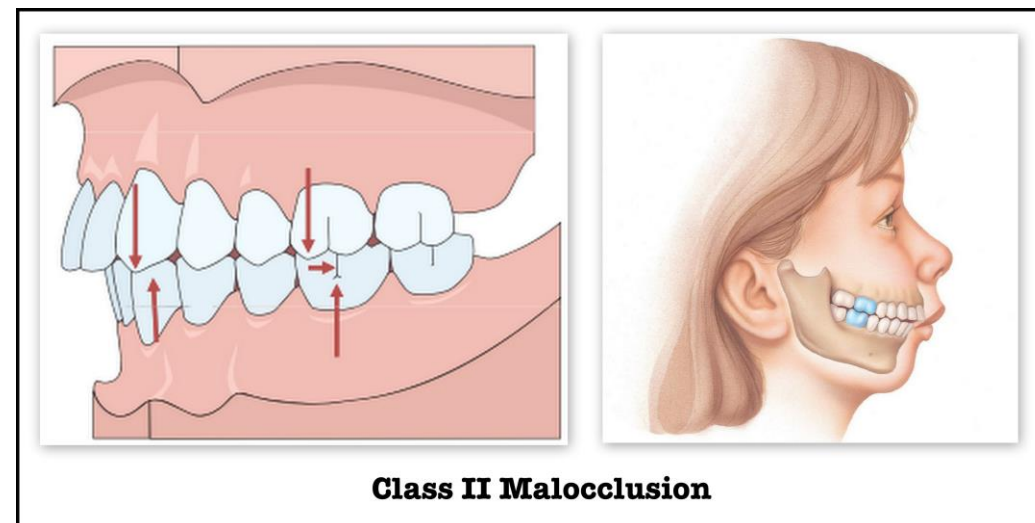
- Thin nasal passageways
- Patient always feels congested even though nasal passageways and sinuses are clear
- Possible ENT referral for turbinate coblation



3. Diagnostics for dental/skeletal relationships

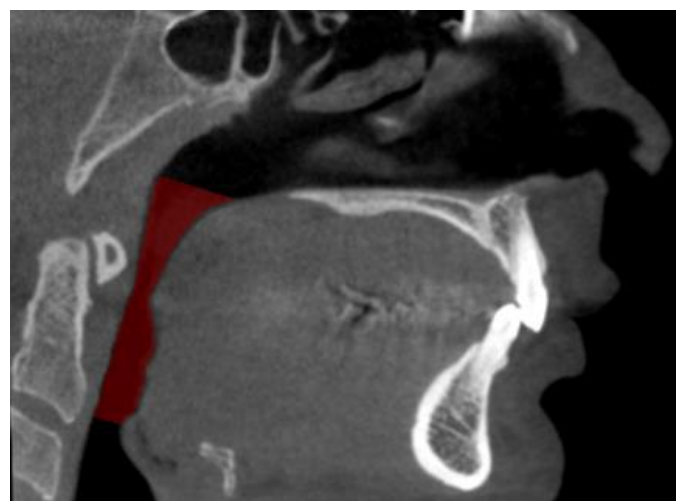
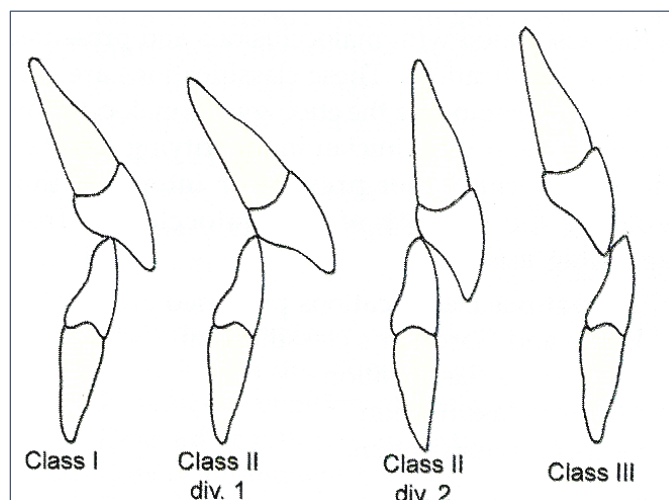
Orientation

- Dental vs skeletal classifications
 - Orthodontics often camouflages a patient's real skeletal relationship
- “The cage of the tongue” concept



3. Diagnostics for dental/skeletal relationships

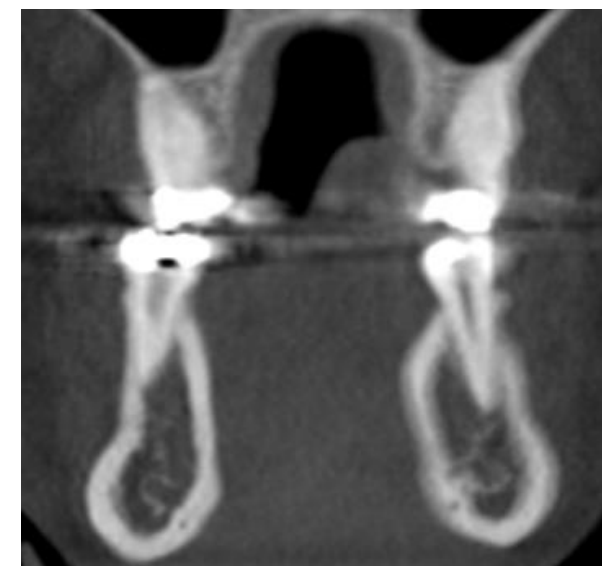
Class II Division II



3. Diagnostics for dental/skeletal relationships

Cross-bite

- Narrow maxillary arch (micrognathia)
 - Less developed nasal cavity
- Lingual tipped mandibular molars
- Less space for tongue
 - Encourages/caused by low and posterior tongue posture
 - Related to falling backwards while sleeping
 - Also associated with mouth breathing

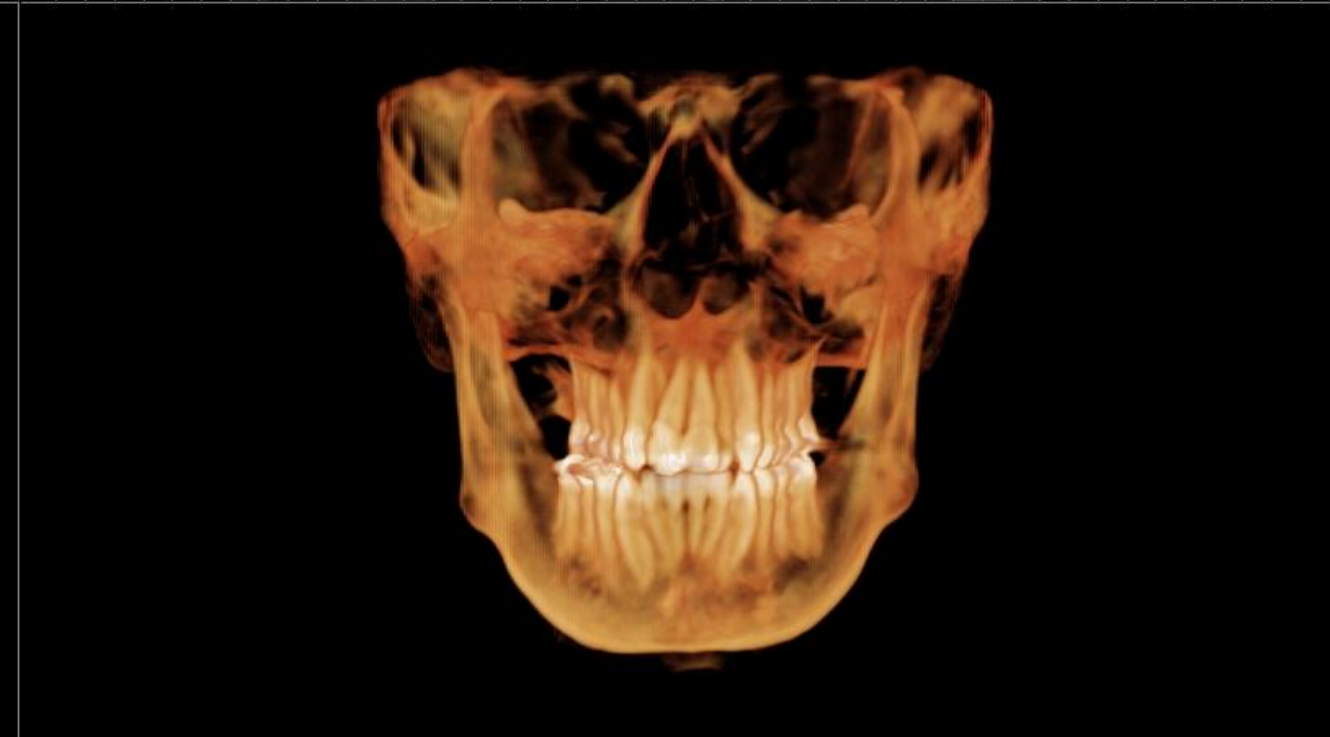
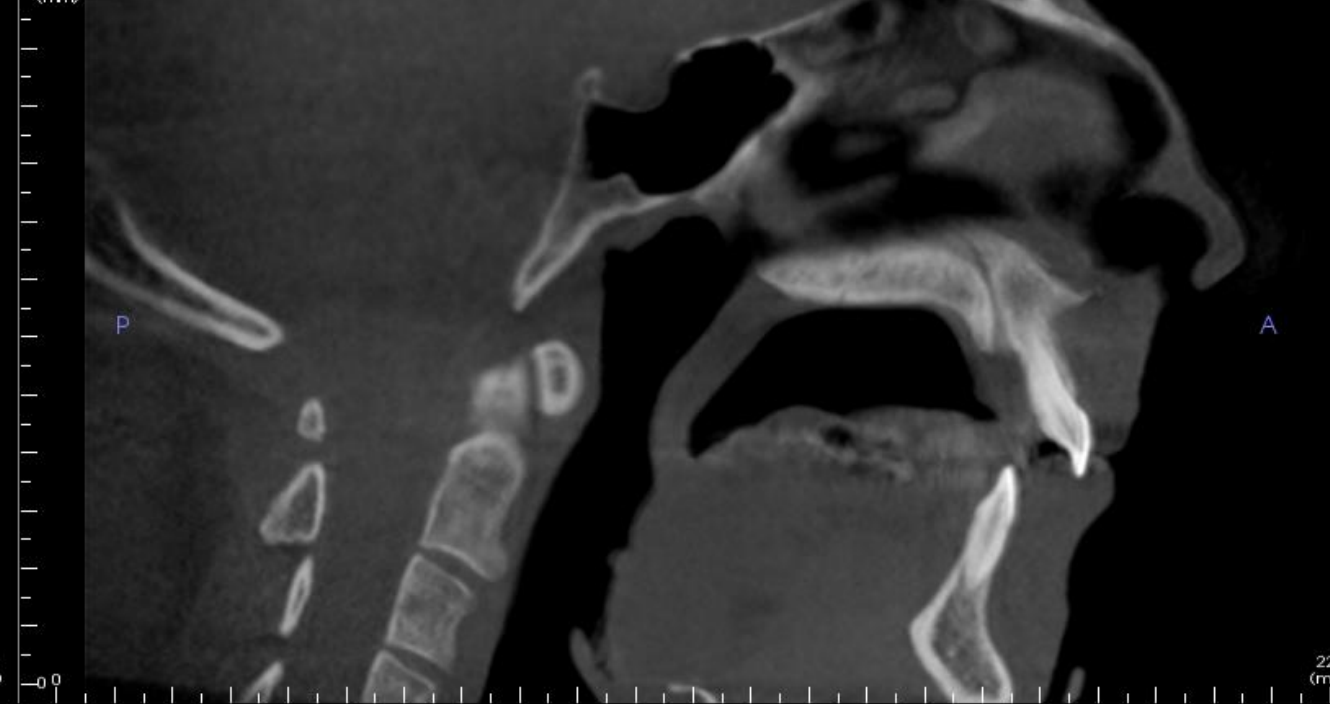


3. Diagnostics for dental/skeletal relationships

Steep Palatal Vault

- Steep palatal vault
- Narrow maxillary arch
 - Due to mouth breathing
 - The tongue is not applying natural “orthodontic” force laterally to expand the maxillary arch
 - Septum deviation
- Less space for tongue
 - Encourages/caused by low and posterior tongue posture
 - Related to falling backwards while sleeping

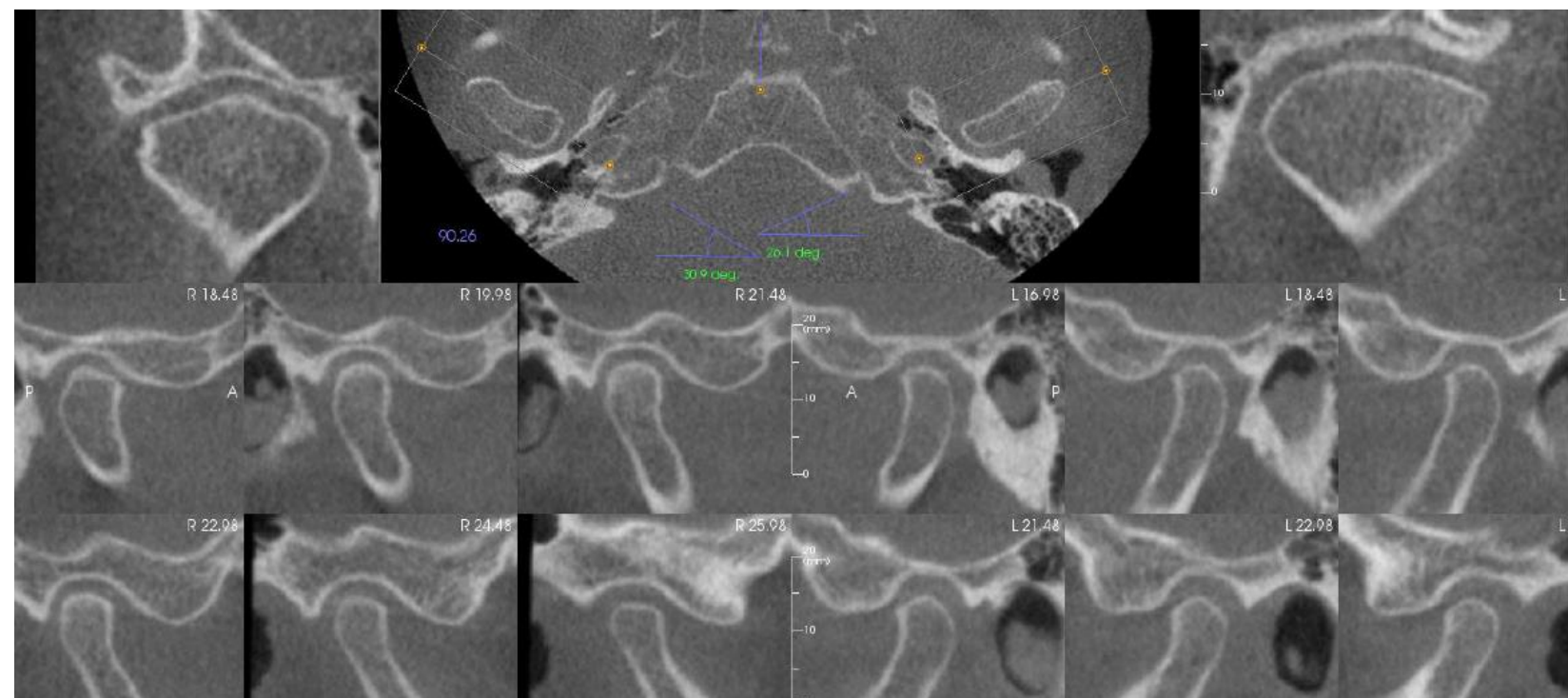




4. Diagnostics for TMJ and cervical vertebrae

Sample Case

- Functional Remodeling



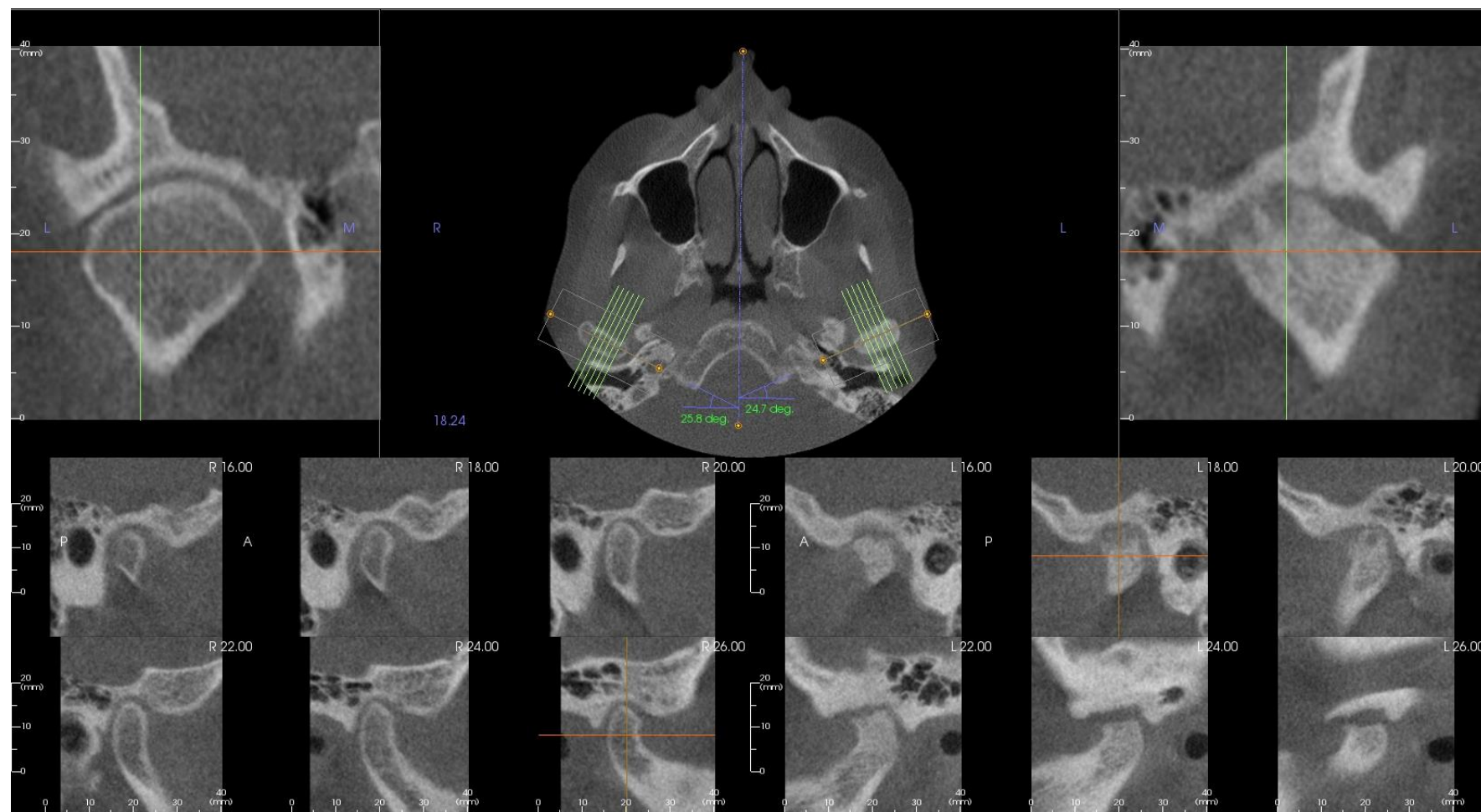
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Mildly flattened areas with intact cortical borders at the anterosuperior aspects of the right and left condyles is consistent with functional remodeling, which is an adaptation of the joints to functional stresses. Contours and cortical borders of the articular eminences appear normal, and the condyles are concentrically located within the fossae. Unless symptoms of temporomandibular joint disorder are observed, intervention does not radiographically appear necessary.

4. Diagnostics for TMJ and cervical vertebrae

Sample Case

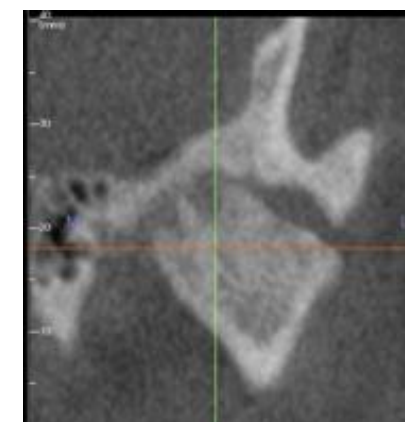
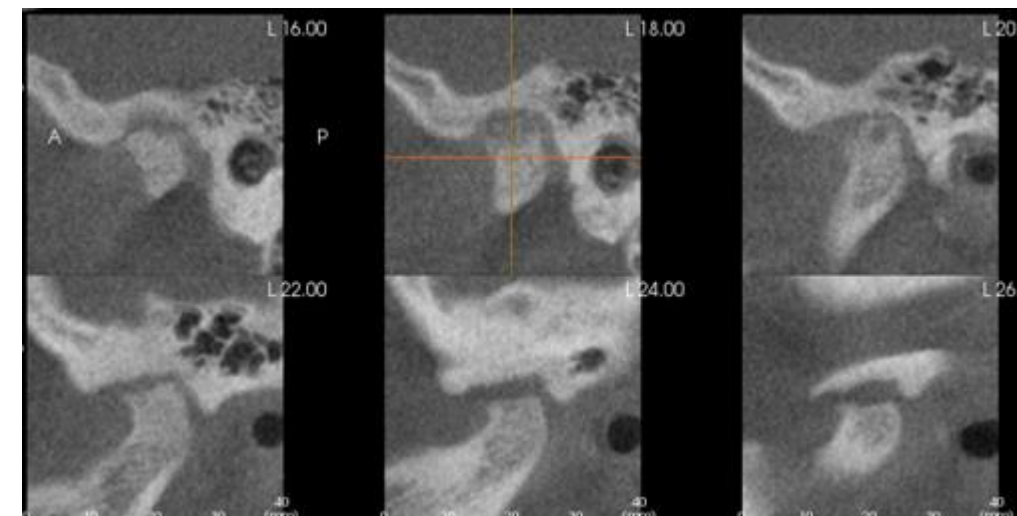
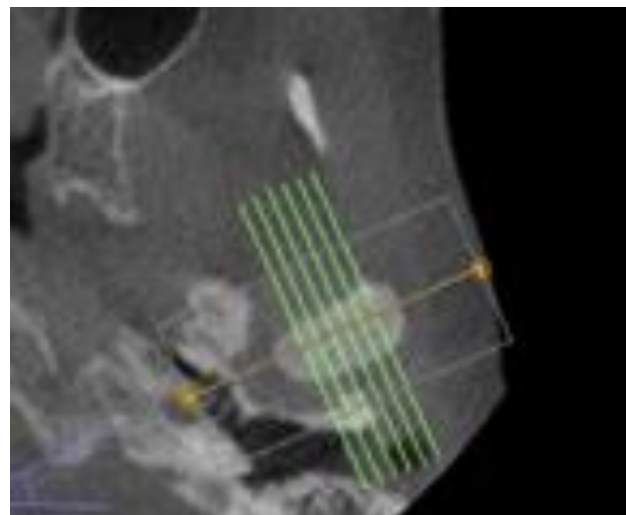
- Sever Active DJD



4. Diagnostics for TMJ and cervical vertebrae

Sample Case

- Sever Active DJD



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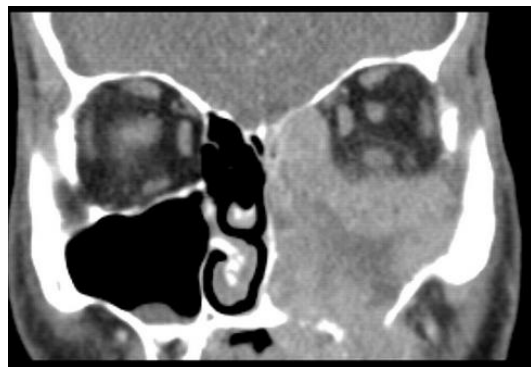
Left temporomandibular joint: degenerative joint disease, severe, active (see Comment).

Comment: the appearance at the left condyle suggests the degenerative process is active. Degenerative processes of the temporomandibular structures involve the destruction of the articular tissues and occurs when the remodeling capacity of those tissues has been exceeded by the functional demands. The presence of the degenerative process increases the probability of displaced and perforated articular soft tissue, decreased range of motion, may be associated with a change in occlusion and mandibular posture, and may predispose the joint to dysfunction and pain. CBCT does not reliably portray joint soft-tissue status and cannot rule out contributory factors such as muscle irregularities, articular soft-tissue conditions, or para-functional habits should TMD symptoms be present. Further assessment should be performed to confirm presence of degenerative joint disease and rule out other more nocent process.

5. Diagnostics for Oral Maxillofacial Pathology

The role of the Oral Maxillofacial Radiologist and Radiology Reports

- CBCT imaging provides an excellent pathology screen tool
- All radiographic images must be read and interpreted (Pano, PA, bitewing, CBCT...)
- In dentistry, general dentists can do procedures in the domains of specialists provided that they do it to the same standard of care as the specialist
 - The reading of radiographs is not an exception to this general rule
- Oral maxillofacial radiology and oral pathology are extremely vast sciences
- Partial-read consent forms are not valid nor professional



5. Diagnostics for Oral Maxillofacial Pathology

My view of the radiology report

- It is a service to the patient
- It distinguishes my practice by having another highly trained professional involved
- It provides legal protection
- It is a continuing education lesson for myself
- It augments and validates my examination process
- It is an excellent communication and referral tool for other dental and medical professionals
- In the medical arena, radiology reports are an expected standard for any type of CT image

BeamReaders
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Patient: Frank
DOB: 03/13/1961
Ref. Doctor: Douglas L. Chenin, DDS
Study Purpose: TMJ Orofacial Pain, Sinus Evaluation
Airway Evaluation, Orthodontic Evaluation
General Review
Dr. Notes: Mr. Frank has been diagnosed with OSA. Please provide a full pathology screening and dental-skeletal orthodontic relationship assessment, as well as airway, sinus, nasal passageway, and TMJ assessments.

Report Date: 04/13/2017
Study Date: 04/07/2017
Scan Source: San Francisco Dental Sleep Medicine

OBSERVATIONS:
DENTITION:
Missing: #1, 16, 17 and 32 were missing.
RCT: #14 and 19.

ALVEOLAR BONE:
-Generalized mild horizontal bone loss was observed. Radiographic artifacts from metallic restorations may compromise bone level assessment; please correlate these findings clinically to rule out active periodontal disease.
-Defined, non-corticated hypodensity were noted surrounding the MB apex of #14. This is consistent with rarefying osteitis, mostly endodontic in origin. To establish a differential diagnosis between active periapical osteolysis and endodontic healing process, please correlate with previous clinical information (e.g. X-rays).

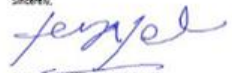
AIRWAY:
-Nasal septum deviation was noted. The soft palate was approximately 49 mm long.
-The space posterior to the tongue and soft palate was reduced (approximately 62 mm³). This space is small and should be considered an intermediate risk factor for obstructive sleep apnea (OSA).

SINUSES:
-The right maxillary sinus was hypoplastic.
-Signs of slight increase in the mucosal thickening were noted from the floor and walls of the right maxillary sinus and from the floor of the left maxillary sinus. This is consistent with allergies or another condition of inflammatory origin (sinusitis). The anatomical complexes were patent/clear.

TMJ:
Right and Left: The condyles were small. The reduction in size occurred along the superior surface of the condyles (vertical dimension). Evidence of flattening and osteophyte formation for the superior/anterior surface of the condyles and sclerosis for the posterior slope of the eminence was noted.
Position: When the mandible was in "closed" position the condyles were positioned posterior to the center in their respective fossae. The posterior articular spaces were reduced. Condylar translation was not evaluated at this study.

OCCCLUSION:
OTHERS: -Signs of bilateral Molar Class I relationships and suggestive evidence of deep overbite (OB) were observed.
-Bilateral elongation/calification of the styloid-hyoid process/ligaments was observed. This is a normal anatomic variant; if pain is related to this finding then Eagle Syndrome should be considered in the differential diagnosis.

IMPRESSIONS:
• Airways: The findings described above should be considered risk factors for obstructive sleep apnea (OSA).
• TMJs: The findings described above are most consistent with NON-ACTIVE degenerative joint disease (DJD) for the TMJs. DJD involves the destruction of the articular tissues and may occur when the remodeling capacity of those tissues has been exceeded by the functional demands. The presence of these changes increases the probability of displaced discs in the TMJs. Reduction of condylar size may be associated with changes in occlusion, asymmetries and mandibular posture which may predispose to TMJ dysfunction. The posterior positioned condyles within their fossae may predispose to anterior displaced discs and compression of the posterior surface of the condyles and the adjacent retrodiscal tissues.
• Most of the other findings and their correspondent diagnosis were noted above. Please correlate the sections with the axial and panoramic views for additional diagnosis and treatment planning purposes. Reviewing the remaining available volume, there was no evidence of any other anomaly/pathology in the maxillofacial and surrounding structures available in this study.

Sincerely,

Francisco Eraso, DDS, MS, MSD,
Oral & Maxillofacial Radiologist

* The thumbnail images in the report are for reference only.

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Summary – The Role of CBCT in Dental Sleep Medicine

- Limitations

- CBCT imaging is not diagnostic for Sleep Related Breathing Disorders
- Does not substitute polysomnography

- Advantages

- Assessment tool for the airway, nasal passageways, and sinuses
- Diagnostic for oral maxillofacial pathology relating to the airway, sinuses, temporomandibular joints, cervical vertebrae, and dental/skeletal anatomy
- Provides a three-dimensional baseline of patients anatomy
- Provides another type of sleep screening tool for cases where the CBCT image was initially captured for implant planning, endodontics, or other procedures
- Provides an excellent communication and referral tool for other dental and medical professionals (provided a radiology report is utilized)

Thank you!!!

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